

Effect of Temperature on pH Meter Based on Arduino Uno With Internal Calibration

Lilia Wati Dewi Pratami[#], Her Gumiwang Ariswati, Dyah Titisari
Department of Electromedical Engineering Poltekkes Kemenkes, Surabaya
Jl. Pucang Jajar Timur No. 10, Surabaya, 60245, Indonesia
[#]liliawati48@gmail.com, ariswatihergumiwang@gmail.com, ti2_sari@yahoo.com,

Article info: Received May 24, 2019; Revised July 4, 2019; Accepted January 6, 2020

Abstract—pH Meter is a device used to express the level of acidity or basicity possessed by a substance or solution. Normal pH has a value of 7 while the pH value > 7 indicates that the substance has alkaline properties while the pH value < 7 indicates acidic properties. pH 0 shows a high degree of acidity, and pH 14 shows the highest degree of alkalinity. pH Meter reads the pH and temperature values in a sample. The author uses glass electrodes as a pH sensor, DS18B20 as a temperature sensor and LCD to make pH and temperature values. This module is equipped with an internal calibration that is used to set the module to read the pH value properly and correctly using a pH buffer and equipped with internal storage and this module facilitates battery usage. Based on pH measurements on the module the error value in buffer 4 calibration is 5.39%, in buffer 7 is 1.76%, in buffer 10 is 1.04%. The highest error value in the measurement sample is 3.54% and the lowest error value is 0.03%. The temperature of the sample is very influential in the reading of the pH value because the higher the temperature the pH value also increases even though it is not so significant.

Keywords—pH meter; Electrode; DS18B20

I. INTRODUCTION

pH or acidity is used to express the level of acidity or base that is possessed by a substance, solution or object. Normal pH has a value of 7 while the pH value > 7 indicates that the substance has alkaline properties while the pH value < 7 indicates acidity. pH 0 shows a high degree of acidity, and pH 14 shows the highest degree of alkalinity. Generally, the simple indicator used is litmus paper which turns red when its acidity is high and blue if its acidity is low. pH meter is a laboratory equipment used to determine the acidity or basicity of a solution. pH meters have electrodes used for sensors or detectors. Electrodes are usually made of glass and at the bottom, there is a bulb which is a sensitive part of the electrode, so the bulb is cleaned using soft tissue paper and should not be touched by hand. The benefit of a pH meter is that it allows the user to measure pH because the measurement results are in the form of digital numbers and have accurate values rather than using litmus paper. pH is the acidity level used to express the acidity or alkalinity level of a solution. The term "pH" was first described by Danish biochemist S.P.L. Sorensen in 1909. pH stands for "hydrogen power" where "p" stands for the German word for power potential, and H is the element symbol for hydrogen [1]. In principle, the measurement of a pH is based on the electrochemical potential that occurs between the solution contained in the glass electrode (glass membrane) which has been known with the solution contained outside the unknown glass electrode. This is because the thin layer of glass bubbles will interact with hydrogen ions which are relatively small in size and active, the glass electrode will measure the electrochemical potential of hydrogen ions or termed the potential of hydrogen. To complete the electrical

circuit a comparative electrode is needed. For the record, the device does not measure current but only measures voltage [2].

The pH meter was made by (Tetelepta, 2015) [3] entitled "Microcontroller Based ATmega 8535" pH Meter in the Surabaya Ministry of Health Polytechnic Department of Electromedical Engineering. This study was designed to measure pH levels using ATmega 8535 microcontroller as a data processor and internal storage, but this tool has not been able to compensate for the measurement results with the temperature of the sample. The pH meter was made by (Rahmania, 2018) [4] entitled "Designing Arduino Uno-Based PH Meters" in the Surabaya Ministry of Health Polytechnic Department of Electromedical Engineering. This research was designed to measure pH and temperature levels in a sample. This system uses pH sensors and temperature sensors as detectors and uses Arduino Uno as a data processor, but this tool is not equipped with batteries and data storage. Based on the identification of the previous research, there are some disadvantages in making a tool such as a tool not yet equipped with a temperature sensor, the device still uses the ATmega microcontroller as a data processor, the tool is not equipped with storage, and the device has not used the battery as a power supply. Therefore the author will make "The Effect of Temperature on pH Meter based Arduino Uno equipped with Internal Calibration" which can measure pH and temperature in a sample using Arduino Uno microcontroller as a data processor and is equipped with internal storage and using batteries as a source of power supply so that can be used easily and practically, and the author will analyze the effect of temperature on pH measurement.

II. MATERIALS AND METHODS

A. Experimental Setup

This study used ten samples and three temperature points. Data collection is repeated five times.

1) Materials and Tool

This study uses a ph meter electrode sensor (SKU: SEN0161) and DS18B20 temperature sensor. The electrode and temperature sensor are dipped in the sample to be measured. Arduino Uno microcontroller is used as a data processor. Arduino EEPROM with 1 kb of memory is used for data storage. digital ph meter and digital thermometer are used as a comparison.

2) Experiment

In this study, after the design is complete, the device is calibrated using a buffer solution. buffer solution used is buffer 4, buffer 7 and buffer 10. Then the device is tested on the sample. The sample used is Le mineral, Cheers, Club, Aqua, Vit, Kangen water, zam-zam water, refill water 1, refill water 2, refill water 3.

B. The Diagram Block

In this study, the sample is inserted into the water bath to warm up and measure the temperature, when the device is ON, the voltage will supply the entire series. After the temperature in the water bath is reached, the ph electrode and temperature sensor are inserted into the sample, the ph meter circuit and temperature sensor read the results of the measurement. The pH measurement data and temperature are processed on the Arduino and the results will be displayed on the LCD.

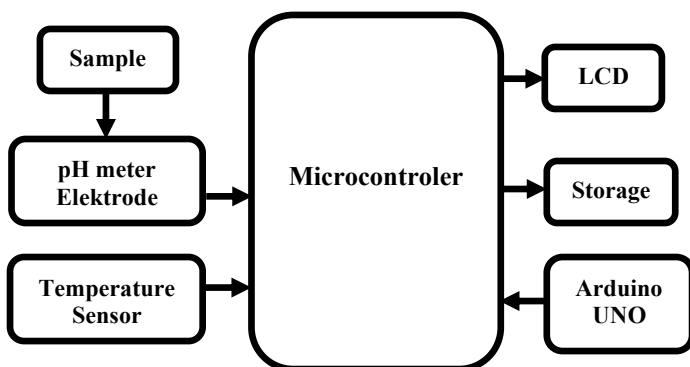


Fig. 1. The diagram block of the pH Meter

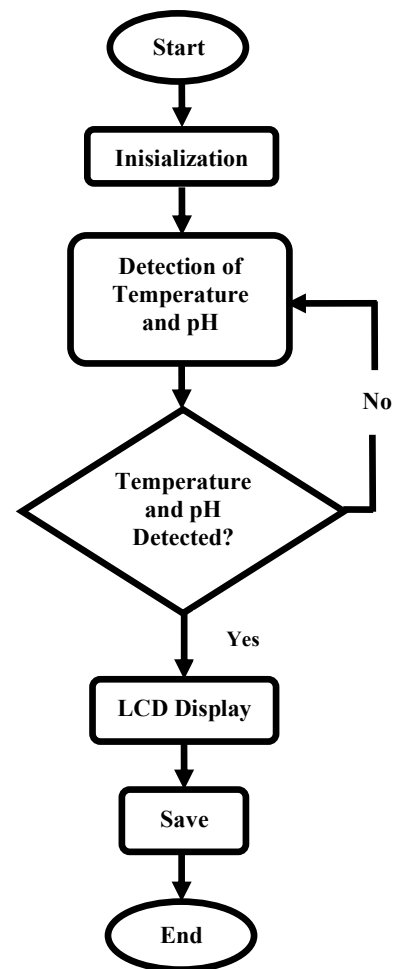


Fig. 2. The Flowchart of the Arduino Program

C. The Flowchart

The Arduino program is built on the flowchart as shown in Figure. 2. After the Arduino initialization, the program will display the results of calibration or measurement namely temperature and pH after which the data is stored on Arduino internal storage

D. The Circuit

The important part of this development is the circuit

1) pH Modul SKU SEN0161

In pH measurement a pH sensor module is used. This pH sensor module consists of 2 parts, namely the pH electrode and the signal conditioning circuit for the pH electrode. Signal conditioning of pH electrodes using an analog pH meter kit from Dfrobot. Because the output of the electrode is too small (mV) and there is also a minus (-) voltage that cannot be processed by Arduino it needs to be amplified with the ph sku module circuit sen0161.



Fig. 3. pH Modul SKU SEN0161

2) DS18B20 temperature sensor

The DS18B20 temperature sensor is a temperature sensor with digital output so that the output can be directly connected to the Arduino digital pin without the need for an amplifier circuit. Communication between DS18B20 and Arduino uses 1-wire communication, that is, the type of communication that requires 1 pin from one of the microcontroller ports. The function of this temperature sensor is to measure the temperature of a sample, the resulting temperature is in units of °C.

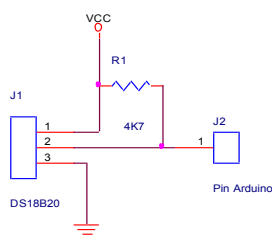


Fig. 4. DS18B20 Temperature Sensors

III. RESULTS

In this study, pH meters were calibrated using a buffer solution and the results showed that it was feasible to take measurements on the sample to be studied.

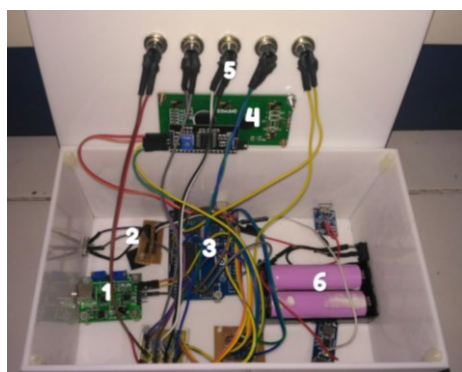


Fig. 5. The pH Meter Design

1) The pH Meter Design

In the picture above is a photo of the inside of the module which consists of the module pH SKU: sen0161 is used to produce a pH value, the temperature sensor is used to produce temperature values, Arduino Uno as a processor, Lcd is used to displaying the measurement results, push-button is used for commands and batteries as a power supply

2) The Listing Program for Converting pH values and temperature.

So that the tool can display the measurement results of temperature and pH, the Listing Program is displayed as Program Listing 1.

Listing program 1. program for converting pH values and temperatures.

```
void loop()
{
  if(waktu <60)
  {
    celsius = (float)raw / 16.0;
    int adcpH = analogRead(A0);
    pH = (adcpH - 1026) / -38.83;
  }
  lcd.setCursor(0,0);
  lcd.print("SUHU= ");
  lcd.print(celsius);
  lcd.print(" C ");
  lcd.setCursor(0,1);
  lcd.print("PH= ");
  lcd.print(pH);
  lcd.print(" ");
}
```

3) Save the result of temperature and pH to Internal Memory

So that the tool can store the results of measurements of internal storage used to store the measurement results. The Listing Program is displayed as Listing Program 2.

Listing Program 2. Program to save the result of temperature and pH to Internal Memory

```
void simpan()
{
  if(cacah == 1)
  {
    lcd.setCursor(0,0);
    lcd.print("SIMPAN 1");
    EEPROM.put(addr1, celsius);
    EEPROM.put(addr2, pH);
  }
}
```

```

}

waktu = 0;
delay(3000);
lcd.clear();
}

void baca()
{
simpan1 = EEPROM.get(addr1, celsius);
simpan2 = EEPROM.get(addr2, ph);

btbacax = digitalRead(btbaca);
btukurx = digitalRead(btukur);
btkalx = digitalRead(btkal);

if(btukurx == 1)
{
delay(200);
lcd.clear();
waktu = 0;
return;
}

if(btkalx == 1)
{
delay(200);
lcd.clear();
waktu = 0;
return;
}

if(btbacax == 1)
{
delay(200);
mark++;

if(mark > 10)
{
mark = 1;
}
}

if(mark == 1)
{
suhu = (simpan1);
phx = (simpan2);
}

lcd.setCursor(0,0);
lcd.print("SUHU= ");
lcd.print(suhu);
lcd.print(" C ");

```

```

lcd.setCursor(0,1);
lcd.print("PH= ");
lcd.print(phx);
lcd.print(" ");

lcd.setCursor(13,1);
lcd.print(mark);
lcd.print(" ");

baca();
}

```

4) The Measurement Result for pH Meters

The author takes measurements on 10 samples and at temperatures of 30, 35, 40. Measures as much as 5 times and takes the average from these measurements. The measurement results are as follows:

Table 1. The Measurement Result for pH Meters

Sample	Temperature (°C)		
	30	35	40
Le Mineral	7,68	7,76	7,90
Chers	7,84	8,01	8,15
Club	7,70	7,85	7,98
Aqua	6,78	7,05	7,39
Vit	7,33	7,37	7,76
Kangen Water	6,89	7,15	7,23
ZamZam	7,90	7,94	8,01
Air Isi Ulang 1	7,62	7,64	7,66
Air Isi Ulang 2	7,09	7,11	7,19
Air Isi Ulang 3	6,82	6,86	6,89

5) Calculation of pH Value at Temperature

Table 2. Calculation of pH Value at 30°C

Sample	Average	Error (%)	Standar Deviasi	UA
Le Mineral	7,68	1,43	0,04	0,02
Chers	7,84	0,13	0,02	0,01
Club	7,70	0,18	0,02	0,01
Aqua	6,78	1,65	0,07	0,03
Vit	7,33	0,27	0,03	0,02

Kangen Water	6,89	1,45	0,02	0,01
ZamZam	7,90	0,86	0,08	0,04
Air Isi Ulang 1	7,62	0,10	0,02	0,01
Air Isi Ulang 2	7,09	0,23	0,07	0,03
Air Isi Ulang 3	6,82	0,18	0,02	0,01

Table 3. Calculation of pH Value at 35°C

Sample	Average	Error (%)	Standar Deviasi	UA
Le Mineral	7,76	0,88	0,04	0,02
Chers	8,01	1,10	0,02	0,01
Club	7,85	1,25	0,05	0,02
Aqua	7,05	0,14	0,04	0,02
Vit	7,37	0,16	0,03	0,01
Kangen Water	7,15	3,02	0,01	0,01
ZamZam	7,94	0,15	0,02	0,01
Air Isi Ulang 1	7,64	0,13	0,01	0,00
Air Isi Ulang 2	7,11	0,31	0,03	0,01
Air Isi Ulang 3	6,86	0,20	0,01	0,00

Table 4. Calculation of pH Value at 40°C

Sample	Average	Error (%)	Standar Deviasi	UA
Le Mineral	7,90	2,23	0,06	0,03
Chers	8,15	2,65	0,03	0,01
Club	7,98	2,10	0,04	0,02
Aqua	7,39	2,30	0,03	0,01
Vit	7,76	2,50	0,04	0,02
Kangen Water	7,23	3,54	0,02	0,01
ZamZam	8,01	0,55	0,02	0,01
Air Isi Ulang 1	7,66	0,03	0,01	0,00

Air Isi Ulang 2	7,19	0,11	0,03	0,01
Air Isi Ulang 3	6,89	0,67	0,05	0,02

IV. DISCUSSION

Based on pH measurements on the module the error value in buffer 4 calibration is 5.39%, in buffer 7 is 1.76%, in buffer 10 is 1.04%. The highest error value in the measurement sample is 3.54% and the lowest error value is 0.03%. The temperature of the sample is very influential in the reading of the pH value because the higher the temperature the pH value also increases even though it is not so significant.

V. CONCLUSION

This study shows the development of pH meters to measure acid and alkaline levels in a sample or solution and is equipped with a temperature sensor. This research was designed using pH modules and temperature sensors and using the Arduino Uno microcontroller as a data processor. This research has proven that accuracy can be used to measure pH and temperature and data can be stored and read on EEPROM data storage. In the future, this study can be carried out at a low cost and has an economical sale value.

REFERENCES

- [1] Tatangsma. (2015, Mei 9). *Pengertian pH dan Rumus pH*. Diambil kembali dari <https://tatangsma.com/2015/05/pengertian-ph-dan-rumus-ph.html>
- [2] Ihsan, A. (2014, November 21). *Makalah ph*. Diambil kembali dari http://awaluddinhsan.blogspot.com/2014/11/normal-0-false-false-false-en-us-x-none_21.html
- [3] Tetelepta, I. S. "pH Meter Berbasis Mikrokontroler ATmega 8535". Surabaya: Poltekkes Surabaya. 2015.
- [4] Rahmania, A. U. *Perancangan PH Meter Berbasis Arduino Uno*. Surabaya: Poltekkes Surabaya. 2018